

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

TIF2721 – INTRODUCTION TO FORMAL METHODS

(All sections / Groups)

29th MAY 2019
9.00 am – 11.00 am
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages with 4 Questions only, excluding the cover page.
2. Attempt ALL **FOUR** out of **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

QUESTION (1)

- (A) A formal specification language is usually composed of three primary components. What are these components? Explain briefly. [3 marks]

- (B) Convert the following English sentences into predicate logic expressions.

1. There exists a smart student.
2. Every student loves some student.
3. Every student who takes Formal Methods passes it.

[3 marks]

- (C) Examine the three relations below:

$$\begin{aligned} \text{relA} &= \{\text{john} \mapsto 51, \text{anne} \mapsto 97, \text{tan} \mapsto 42, \text{ali} \mapsto 51, \text{bob} \mapsto 44\} \\ \text{relB} &= \{21 \mapsto \text{red}, 42 \mapsto \text{black}, 44 \mapsto \text{orange}\} \\ \text{relC} &= \{21 \mapsto \text{blue}, 51 \mapsto \text{green}, 44 \mapsto \text{white}\} \end{aligned}$$

What are the elements of the following relations:

$$\begin{aligned} \text{relD} &= \text{relA} \setminus \{\text{anne} \mapsto 97\} \quad (\text{Set difference}) & [1 \text{ mark}] \\ \text{relE} &= \text{relB} \oplus \text{relC} \quad (\text{Relational overriding}) & [2 \text{ marks}] \\ \text{relF} &= \text{relD} \circ \text{relE} \quad (\text{Relational composition}) & [2 \text{ marks}] \end{aligned}$$

- (D) You are given two Z schemas A and B as defined below:

A	B
$y: 1..100$	$y: \mathbb{N}$
$U: \mathbb{P} \mathbb{Z}$	$U: \mathbb{P} \mathbb{N}$
$y \in U$	$y > 50$

What is $A \vee B$? Show the two necessary steps: Normalization and Linking.

[4 marks]

Continue...

QUESTION (2)

(A) You are given two Z schemas C and D as defined below:

C	D
$x, x', s, s' : \mathbb{Z}$	$r!, t!, s, x : \mathbb{Z}$
$s' = s + x;$ $x' = s' + 10$	$r! = s;$ $t! = x$

Define $C \circ D$ (Schema composition C then D). Show all necessary steps. [6 marks]

(B) What is the main difference between schema composition and schema piping? [2 marks]

(C) Three sequences A , B and C are defined as follows:

$$A = \langle 2, 4, 30 \rangle$$

$$B = \langle 66, 77, 88 \rangle$$

$$C = \langle 101, 102, 103 \rangle$$

Find the following:

i. $(B \hat{\ } A) \hat{\ } (C \hat{\ } A)$

ii. $\text{rev}(C \hat{\ } A) \hat{\ } \text{head}(C)$

iii. $(A \hat{\ } C)$ after 3

[3 marks]

(D) Specify a function (in Z notation) that computes the sum of all numbers in a given sequence of natural numbers. [2 marks]

(E) Specify a function (in Z notation) that computes the sum of all positive numbers in a given sequence of integers. [2 marks]

Continue...

QUESTION (3)

The following state schema *BirthdayBook* records people's birthdays in a database system.

<i>BirthdayBook</i>
<i>known</i> : $\mathbb{P} \text{ NAME}$
<i>birthday</i> : $\text{NAME} \leftrightarrow \text{DATE}$
<i>known</i> = dom <i>birthday</i>

known is the set of names with birthdays recorded, *birthday* is a function which, when applied to certain names, gives the birthdays associated with them, for example:

$$\textit{known} = \{ \text{John, Mike, Susan} \}$$

$$\textit{birthday} = \{ \begin{array}{l} \text{John} \mapsto 25\text{-Mar,} \\ \text{Mike} \mapsto 20\text{-Dec,} \\ \text{Susan} \mapsto 20\text{-Dec} \end{array} \}.$$

- Define (in Z notation), the schemas $\Delta \textit{BirthdayBook}$ and $\Xi \textit{BirthdayBook}$. [4 marks]
- Define (in Z notation), the schema *AddBirthday* to add a new birthday. The name to be added must not already be one of those known to the system. [2 marks]
- Define (in Z notation), the schema *Success* that just produce a report such as "The new birthday has been added" in order to inform user that the operation *AddBirthday* has been successfully carried out. [1 Mark]
- Define (in Z notation), the schema *AlreadyKnown* which describes the conditions when the name to be added is already existed and known to the system and specify an appropriate error report to be produced. [2 Marks]
- Define (in Z notation), the schema *FindBirthday* to find the birthday of a person known to the system. [2 Marks]
- Define (in Z notation), the schema *FindPerson* to find the name of a person using his birthday. [2 Marks]
- Define (in Z notation), the schema *ChangeBirthday* to change the birthday of a person known to the system. [2 Marks]

Continue...

QUESTION (4)

- (A) What does *Data reification* refer to in formal methods? Give a simple example. [2 marks]
- (B) Prove by sequence induction that the operation of set union (\cup) implemented using sequences as defined by the function *append* below is correct.

[X]
$\text{append: seq } X \times \text{seq } X \rightarrow \text{seq } X$
$\forall x: X; \sigma, \tau. \text{seq } X \bullet$ $(\text{append}(\langle \rangle, \tau) = \langle \rangle) \wedge$ $(x \in \text{ran } \tau \Rightarrow$ $\quad \text{append}(\langle x \rangle \frown \sigma, \tau) = \text{append}(\sigma, \tau)) \wedge$ $(x \notin \text{ran } \tau \Rightarrow$ $\quad \text{append}(\langle x \rangle \frown \sigma, \tau) = \langle x \rangle \frown \text{append}(\sigma, \tau))$

[5 marks]

Hints: To prove that *append* correctly models (the union operator \cup), we have to show that: $\text{ret}(\text{append}(\sigma, \tau)) = (\text{ret } \sigma) \cup (\text{ret } \tau)$. You have to prove both the base case and the inductive step.

- (C) Find the weakest precondition P for each of the following Hoare triples.

- $\{ P \} x := 3 \{ x+y > 0 \}$
- $\{ P \} x := 3*y + z \{ x * y - z > 0 \}$

[3 marks]

- (D) Briefly describe the FIVE steps in the process of developing and using formal specification. [5 marks]

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